Tech *Notes*

Adding Automation and Decision Support Capabilities at the Reagan Test Site

New software tools provide operators with automated decision support for directing sensors during increasingly complex tests conducted at the Reagan Test Site.

The U.S. Army's Reagan Test Site (RTS), approximately 2300 miles west southwest of Hawaii on the Kwajalein Atoll in the Marshall Islands, is ideal for missile and interceptor testing because of its distance from populous areas and its open-ocean line from launch facilities at Vandenberg Air Force Base in California. The site's unique instrumentation systems, including high-fidelity metric and signature radars and optical sensors, support research, development, test, and evaluation of technology for ballistic missile defense and space surveillance.

Each year, Department of Defense agencies execute many tests to study the flight characteristics and capabilities of missiles, interceptors, and satellites, and to verify their functionality, efficiency, and reliability. Vast amounts of radar, optical, and telemetry data are collected during these tests. Because these tests are growing in complexity, such as having to track multiple simultaneous intercepts by several fielded weapons systems (e.g., Patriot and Aegis), data collection is becoming increasingly difficult for the operators of the sensors, particularly if tests deviate from the prescripted plan (a non-nominal situation). When a test is nominal, sensor

Operators of the Reagan Test Site range control center, shown at their mission terminals, must make real-time decisions based on complex, potentially ambiguous data. The RTS Automation and Decision Support system allows operators to focus on the key data for decision making during these increasingly complex tests.

operators follow a predefined routine; but when a test turns non-nominal, operators must make critical decisions in real time about which contingency plan to use and, for example, how to allocate the limited sensor tracking and data collection resources among the many objects in flight or about to be launched. Often, the contingency plan that makes the best use of limited sensor resources is not an obvious choice because fewer or more targets than expected are in flight. A stressed operator's erroneous decision on which object to track can result in a failure to capture important data; for example, radar data are collected on a low-priority object instead of on a high-priority one.

To significantly reduce the risk of inadequate data collection during tests, MIT Lincoln Laboratory initiated the RTS Automation and Decision Support (RADS) program to develop tools to automate data collection and provide decision support to mission controllers and system operators. The RADS concept calls for building computer software that automatically performs tasks that are well defined by a set of rules and a sequence of instructions, for example, using predefined waveforms over a specified time period during the test. For tasks that involve judgment and abstract thinking, the developers are designing automated decision support algorithms that can help operators choose optimal courses of action.

Elements of RADS

One of the new technologies under development for the RADS program is the unified sensor control software that processes metric, signature, optic, and telemetry data.

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This software presents users with high-level information, such as comparisons of the trajectories under test to the expected trajectories, expected versus actual object counts, radar cross-section values, and the point of impact of each object. To help operators monitor sensors and make better-informed real-time decisions, the sensor control software also provides displays of mission-status information, including the phase of the test, the state of the sensors, and the likelihood of data-collection objectives being met. The information relayed by these displays helps operators determine when to override automated functions and what high-level commands to send to the mission control center and the individual sensors. Ultimately, this software will enable personnel to control the RTS sensors as a single, unified system.

RADS is being built upon the existing command-and-control software infrastructure that was recently modernized through several major upgrades to the sensors and control center at RTS. The upgrade projects implemented modular open-systems designs; publish/subscribe middleware for communication between components; and modern operating systems, computers, and displays. The modular open architecture is key to RADS because it enables not only the real-time data but also the command interface to be exposed to each component.

RADS Automation Tools

The automation tools are divided into two main modules: mission and sensor. The mission module observes the state of the mission and dynamically assigns tasks to RTS sensors on the basis of the mission's goals and the available sensor resources. A typical task is dispatching a sensor to collect a given set of data on a given object; for instance, the Millimeter Wave Radar could be directed to collect wideband data on a reentry vehicle. The sensor module receives the high-level task and decomposes it into low-level sensor commands, such as selecting the waveform to be used.

Mission Module

Of the many components that make up the mission module, the five described here are its backbone.

The *track association and fusion algorithm* produces a single, fused "best track"
for each object under observation. During a test, hundreds of sensor tracks may be produced, including dozens of tracks of the same object. Each of the radars at RTS has both single-target and multitarget trackers that can produce multiple simultaneous tracks on an object. In addition, the control center can run filters, such as a smoothing filter to dampen noise, on any one of the radar tracks, thereby producing more tracks of the same object. The algorithm first correlates all these tracks of an object and then fuses them into a single track to significantly reduce the number of tracks that RADS must process.

To isolate data collection on the specific objects of interest, it is important for mission operators to identify the various objects the sensors are tracking. Currently, operators identify objects by using a priori information and heuristics—for example, relative range spacing between objects, trajectory characteristics (altitude and elevation), and target impact prediction—developed from previous similar flight tests. The RADS *object identification component* automates the collection and analysis of those heuristics and combines the analysis results with information such as beacons on the objects and telemetry data to provide object recognition.

The main processing loop of the mission module dynamically assigns and tasks sensors during the mission. The iterative assign and task loop is executed by three components:

- The *event processor* determines the high-level state of the mission by monitoring events such as information from uprange sensors, mission time, sensor deployments, object counts, and impact predictions. This processor uses RADS' a priori information about events to ascertain mission state and to select the active set of data-collection tasks, which are then passed to the sensor assignment component.
- Overall objectives for a mission are predefined by a mission planner who specifies the type of data to be collected on each object, entry and exit conditions, and priorities. However, the planner does not allocate the sensors that should be used to complete the mission objectives; rather, the *sensor assignment component* has this responsibility, gen-
erating these assignments dynamically during the mission on the basis of sensor availability and a probabilistic value function that maximizes the value of each sensor assignment to a task. The mission plan, which contains sensor assignments and time spans for those assignments, may evolve as events and mission states change.
- Each mission plan that is generated is sent to the *sensor tasking component*, which then consigns the main task of tracking an object to a designated sensor at the appropriate time. The sensor tasking component monitors each sensor to verify that it is executing its assigned tasks. The processing loop continues as this sensor status information is sent back to the event processor and sensor assignment components.

This mission module was developed to transition the current methodology for managing data-collection missions from a predefined, static sensor plan to a continually updated, goals-driven plan. While the goals are defined before the mission, the sensor assignments are generated autonomously during the mission to handle evolving nominal and non-nominal occurrences.

The RADS system will change the concept of operations for collecting sensor data during test and space missions from one that relies heavily on human operators to one that automates many operator actions through the use of enhanced decision support tools and displays. These tools, designed to relieve system operators of many routine determinations, will allow operators and mission controllers to concentrate on managing complex or non-nominal tests and on assuring data-collection requirements are met. ∎

Technical Point of Contact
Timothy O'Rourke
Advanced Sensor Systems and Test Beds
orourke@ll.mit.edu
781-981-4223

For further information, contact
Communications and
Community Outreach Office
MIT Lincoln Laboratory
244 Wood Street
Lexington, MA 02420-9108
781-981-4204